# Draft CEC PIER-EA Discussion Paper

# Forestry

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## Disclaimer

The purpose of this paper is to inform discussions among CEC staff, other state agency staff, non-governmental representatives, representatives of academia and other stakeholders regarding the state of the research on forestry mitigation and adaptation to climate change in California. In particular, this discussion paper will identify gaps in our understanding and recommendations for future research initiatives with the end goal of supporting informed and systematic planning for climate change. Note that this paper is not a research proposal and should not include recommendations regarding specific research projects.

### 1.0 Description of Research Topic

Forests occupy 12.4 million hectares in California, nearly one-third of the land base (FRAP, 2003). Conifer and hardwood forests provide a variety of goods and services to the people of California. Urban forest trees provide the highest individual-tree value in both monetary and climate mitigation contexts (McIntyre, 2008; McPherson et al., 2001). Biomass energy (PIER, 2006), biofuels (Pena, 2008), hydrologic cycling, energy conservation, urban heat island effects, carbon storage and emissions, building material tradeoffs on greenhouse gas emissions (Lippke et al., 2004), as well as the co-benefits of wildlife and fish habitat, aesthetics, outdoor recreation, timber, and travel industry economic impacts are some of the factors that make forests so important in the context of climate change.

In the 2003 PIER research plan, forests were noted for terrestrial sequestration, potential vegetation type changes, ecological impacts from climate change, urban encroachment, bioenergy feedstocks, wildfire and insect/disease impacts, offset markets, and adaptation strategies. Progress has been made on many fronts since the 2003 plan. Climate mitigation (terrestrial sequestration) planning has moved forward through forest sector protocol development and updating by the California Climate Action Registry (CCAR), and under the Air Resources Board (ARB) implementation planning for the Global Warming Solutions Act of 2006. Forest management projects have been registered and verified with CCAR and sold in the voluntary market. The ARB draft scoping plan includes a forest sequestration contribution of 5 million metric tons $CO_2$-equivalent per year by 2020.

Rapidly increasing oil prices, unrelated to climate change regulatory mitigation, have produced a more favorable economic scenario for alternative energy and fuels. Cellulosic ethanol, made from wood fiber, may provide a low-greenhouse gas (GHG) transportation fuel without the potential ecological impacts of land-use conversion and food supply impacts of corn ethanol. Properly implemented, wood-based bioenergy and biofuel could also produce the co-benefits of wildland fire impact reduction, habitat restoration, and improved ecological resiliency to climate change effects.

Climate change is occurring, and the effects are evident in California forests. Several factors make forestry unique in considering adaptation to climate change. First, trees are relatively long-lived and a community response may be different in mature trees versus seedlings; thus delaying indications of species range shifts. Management planning in forestry necessarily requires long-term planning, an advantage when considering climate change. Second, there is a long history of professional forest management that collects genetic material (seeds) by appropriate latitude and elevation, grows superior phenotypes in nurseries, and plants trees in prepared seed beds where survival is maximized. Trees may therefore have advantages over species not able to migrate quickly. Third, forests are interrelated to many other values of interest in climate change mitigation and adaptation. Water supply, species diversity, watercourse peak flow reduction, erosion control, contributions to a low-carbon economy, and regional economic vitality are some of those values.

A strong demand exists for information about forest impacts on and as a result of climate change. In June 2008, the journal *Science* published a special issue titled, *Forests in Flux*. The leading editorial piece concluded with the following (Sukumar, 2008):

> *Given environmental variability and the long-lived nature of trees, long-term studies with comprehensive mandates extending from basic to applied research are likely to be the most useful in providing the scientific basis for sustainable forest management.*

This is not news to forestry researchers (Powers, 1999). Long-term research has always been a goal, but success has been mixed. The value of long-term data that was robustly designed and meticulously cataloged has seen a resurgence in value with the growing issues surrounding climate change (e.g., FIA, 2008; Kelly et al., 2005; van Mantgem and Stephenson, 2007).

Policy decisions on climate change will not wait for new long-term studies to be developed. We must use the best available information now while planning to improve our knowledge for adaptive management of forests. Understanding the general state of forestry research is useful for planning.

The National Research Council (NRC) published a report titled, *National Capacity in Forestry Research* (NRC, 2002), which mostly focused on the larger institutions of the federal government and state university systems. The following is, in part, a conclusion of the Council:

> *What is necessary is a concerted, permanent cooperative effort among many stakeholders, which includes joint strategic planning and monitoring; continued support of existing organizations and fundamental and emerging research; a larger and open cooperative grants programs from the Forest Service; broader training for forestry graduate students; and an integrated research, education, and extension enterprise.*

A follow-up article by Sharon Freidman, Chair of the Society of American Foresters' Forest Science and Technology Board, added an important point missed in the Council's report—the need to make research relevant to the user community (Friedman, 2002):

> *Good scientific research is research that is adopted by users and contributes to sustainable development, environmental protection, and community welfare.*

Friedman suggests that ways to accomplish this are to employ business strategies, such as market research and focus groups, when the research is applied. This corresponds with the stated objectives of the PIER research on climate change.

The sequestration potential of terrestrial systems is projected to increase and then peak mid-century (IPCC, 2007). The challenge then will be to avoid emissions. Given historic cutting patterns and current private and public land management policies, a similar pattern is likely for California.

Climate change mitigation, adaptation, and monitoring should be strategically planned across government, academic, and professional stakeholders. The forest industry in California has a history of supporting research cooperatives when benefits can be clearly demonstrated. Joint planning will optimally allocate scarce resources and provide leverage for obtaining additional resources.

## 2.0 Summary of PIER Program Research to Date Related to Climate Change and Forestry

This section lists the PIER program research related to climate change and forestry in two parts: the first lists projects with direct forest research goals, and the second lists selected projects with indirect links.

### 2.1 Direct Forestry Research

- Global Climate Change and California: Potential Implications for Ecosystems, Health, and the Economy (Wilson et al., 2003).
- Carbon Supply from Changes in Management of Forest, Range, and Agricultural Lands in California (Brown et al., 2004.)
- Baseline Development and Estimation of Carbon Benefits for Extending Forested Riparian Buffer Zones in Two Regions: Blodgett Forest Research Station and Jackson State Demonstration Forest (Brown et al., 2004).
- Measuring and Monitoring Plans for Baseline Development and Estimation of Carbon Benefits for Change in Forest Management in Two Regions: Changing from Even-Age Management with Clearcuts to Uneven-Age Management with Group Selection Harvests (Brown et al., 2004).
- Methods for Measuring and Monitoring Forestry Carbon Projects in California. (Brown et al., 2004).
- Climate Change and Wildfire in and around California: Fire Modeling and Loss Modeling (Westerling and Bryant, 2006).
- Climate Change-Projected Santa Ana Fire Weather Occurance (Miller and Schlegel, 2006).
- The Response of Vegetation Distribution, Ecosystem Productivity, and Fire in California to Future Climate Scenarios Simulated by the MC1 Dynamic Vegetation Model (Lenihan et al., 2006).
- Fire and Sustainability: Considerations for California's Altered Future Climate (Moritz and Stephens, 2006).

- Climate Change Impacts on Forest Resources (Battles et al., 2005).
- Predicting the Effect of Climate Change on Wildfire Severity and Outcomes in California: A Preliminary Analysis (Fried et al., 2006).
- Baseline Greenhouse Gas Emissions and Removals for Forest and Rangelands in Shasta County, California (Pearson et al., 2006).
- Carbon Supply from Changes in Management of Forest, Range, and Agricultural Lands in California: Forest Fuel Reduction (Petrova et al., 2006).
- Carbon Supply from Changes in Management of Forest and Rangelands in Shasta County, California (Brown et al., 2006).
- The Development of 70-Year-Old Wieslander Vegetation Type Maps and an Assessment of Landscape Change in the Central Sierra Nevada (Thorne et al., 2006).
- Assessing Impacts of Rangeland Management and Reforestation of Rangelands on Greenhouse Gas Emissions: A Pilot Study for Shasta County (Salas et al., 2007).

Some of these PIER reports resulted or contributed to publications in scientific journals, such as Westerling et al. (2006) and Battles et al. (2008).

### 2.2 Indirect Forestry Research

- Climate Change and the Timing of Songbird Migration in California: Focus on Coastal Central and Northern Regions (MacMynowski and Root, 2006).
- Carbon Sequestration through Changes in Land Use in Oregon: Costs and Opportunities (Dushku et al., 2007).
- Carbon Sequestration Through Changes in Land Use in Washington: Costs and Opportunities (Dushku et al., 2007).
- Measurement of Large Scale Gene Flow: A Pathway Toward Understanding Adaptation and the Genetics of Climatic Tolerance (Hellmann and Zakharov, 2007).
- Baseline Greenhouse Gas Emissions and Removals for Forest and Agricultural Lands in Oregon (Pearson et al., 2007).
- Baseline Greenhouse Gas Emissions and Removals for Forest and Agricultural Lands in Washington State (Pearson et al., 2007).
- Baseline Greenhouse Gas Emissions and Removals for Forest and Agricultural Lands in Arizona (Pearson et al., 2007).

## 3.0 PIER Accomplishments

The 2003 PIER Research Plan had the objectives of improving understanding of climate change impacts on ecological resources, terrestrial sequestration, bioenergy, inventory methods, supply curves, and the economics of mitigation and adaptation. The projects undertaken have been consistent with the plan objectives. Research results have ranged from high-impact top-ranked peer-reviewed journal articles, to the category of first effort reports used for reference only. Particularly considering the fast pace of knowledge development and wide scrutiny climate change now commands, this is a success. Policy development in forestry and climate change for California has relied heavily on the results from PIER research studies.

## 4.0 Non-PIER Accomplishments in this Area and Opportunities for Collaboration

The primary forestry research entities in California are the forestry, natural resources, and agriculture universities of California Polytechnic State University (SLO), Humboldt State University, UC Berkeley, and UC Davis. The largest federal forest research organization is the United States Department of Agriculture (USDA) Forest Service Pacific Southwest Research Station (PSW). Other forest-related research entities include other colleges and universities, university affiliated non-profit foundations, research centers, other federal and state agencies, private consultants, and non-profit organizations. Climate related studies are common at all of these.

Existing research programs have adopted climate change in response to public interest and competitive research funding. While there is great benefit to basic scientific research being ad-hoc in nature, there is also benefit to the coordination of applied research. An example of a networking of existing entities is the participation of the Caspar Creek Watershed Study (USDA Forest Service and Jackson Demonstration State Forest partnership) joining the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT). Another example is the USDA and US Department of Energy (DOE) providing $18 million for research and corporate collaborations in other states (Peña, 2008).

In addition, the National Science Foundation sponsors the National Ecological Observatory Network (NEON), which will consist of 20 permanent locations across the United States and some "portable" stations (Keller et al., 2008). The purpose of NEON is to collect detailed ecological data along with ancillary data to draw inferences to a continental scale. The goal is to characterize ecosystem response to natural and anthropogenic forcings and the feedbacks. In particular, the impact of climate change, land-use change, and invasive species are to be studied, with one of the 20 proposed sites being in California; the Pacific coast of the United States is not well represented in the network. Three of the 20 sites have research questions focused on forestry. Besides the direct scientific research that will be produced, NEON, like the Long-Term Ecological Research sites (LTER), will provide standard measurement and data management protocols that may be used for other research networks.

## 5.0 Research Underway/Committed to via PIER Process

As in Section 2.0, this section lists research underway/committed to via the PIER process in two parts: the first list includes projects with direct forest research goals, and the second list includes selected projects with indirect links.

### 5.1 Direct Forestry Research

- Dynamics of Sierra Nevada Conifer Loss Under Climate Change—James Thorne, UC Davis.

- West Coast Regional Carbon Sequestration Partnership (WESTCARB) Projects, Phase II—Larry Myer, Lawrence Berkeley National Laboratory (LBNL)/PIER.
- Dynamic Ecosystem Modeling for California—Lee Hannah, Conservation International.
- Grinnell Resurvey Project—Craig Moritz, UC Berkeley.
- Collection of Ecological Data for Climate Change Studies—2 projects, RFP under review.

### 5.2 Indirect Forestry Research

- Estimating the Global Climate Impact of Urban Albedo—Hashem Akbari, LBNL. Considers the interactions of urban forest show, including lowering albedo by shading, increasing energy efficiency in structures by shading, general cooling through evapotranspiration; and all the combined potential effects both negative and positive relative to climate change.
- California Autonomous Unmanned Aerial Vehicle (AUAV) Air Pollution Profiling Study—V. Ramanathan, UC San Diego (UCSD). May inform the albedo altering consequences of some forestry projects relative to impacts on snow.
- Development of Probabilistic Climate Projections for California—Dan Cayan, Scripps-UCSD. Will assist in understanding forest response to climate change.
- Biological Impacts of Climate Change in California—Terry Root, Stanford; and Jill Talmage, PRBO Conservation Science (PRBO). Examines a number of ecological aspects, including rainfall pattern change effects on grasslands.
- Climate Adaptation Planning in California using Google Earth/weADAPT: a Pilot Study—David Purkey, Stockholm Environment Institute (SEI). Goal of improving tools in California for adaptation research, decision support and information dissemination.
- Integrated Climate Technology Analysis for California—Steven Smith, Pacific Northwest National Laboratory (PNNL). Develop model for California energy system, which could be useful for bioenergy analyses.

## 6.0 Gaps in Research/Knowledge Relevant to California

The development of four forestry protocols for CCAR and WESTCARB research has pointed to some information gaps. These include reliable tree biomass equations, urban forest indirect effects on energy use, and fuels treatment effects on fire risk reduction to neighboring areas. The efficacy of emissions reduction from wildfire reduction in size and intensity through a program of fuels treatments is another area needing research. The baseline inventory process that ARB went through last year highlighted information gaps in the Forest and Inventory Analysis program due to recent program changes. Robust carbon tracking strategies for the forestry sector are being sought. This includes an inventory of the State's urban forests, which are about 5 percent of the land base.

The GHG production and sequestration from wood production versus alternative building materials, including the economics of substitution, need quantification. The

GHG production and hydrocarbon offsets from wood biomass production—including the economics of substitution—also need quantification. Nearly 80% of the wood products consumed in California are imported; how does this affect in-state GHG accounting and forestry sector economics? Mitigation and adaptation strategies rely on forestry sector infrastructure, and these capacities will be reduced if mills and logging firms continue to decline.

The GHG profile is hypothesized to be relatively low if the lignin waste were used for the energy needed for the fuel conversion process, as is done in Brazil with sugarcane-to-ethanol (Peña, 2008; Williams et al., 2007). Land-use change, fertilizer use, and vehicle efficiencies are some examples of factors that need to be considered in a full life-cycle accounting of GHG profiles. Equitable accounting is critical for low-fuel standard enforcement and genuine effects on the atmosphere.

What is the relative value of old forest structures and intensively managed plantations (Stokstad, 2008)? This is a debate that incorporates life-cycle questions and carbon pool management and response. A significant risk is that litigation, regulation and policy will move quicker than the supportable science.

Impacts to California forests will affect not just the more common ecotypes and species, but also those that are relatively rare or unique to California. These include both the Sierra (*Sequioadendron giganteum*) and coast redwood (*Sequoia sempervirens*), sugar pine (*Pinus lambertiana*), Jeffreyi pine (*Pinus jeffreyi*), bigcone Douglas-fir (*Pseudotsuga macrocarpa*), California red fir (*Abies magnifica*), incense-cedar (*Calocedrus decurrens*), and others. Major and unique species could be monitored for species range expansion or contraction by the strategic placement of long-term monitoring plots.

In addition to carbon cycling and storage, other factors may be important to understand for climate change forestry analysis and policy. For example, what are the total effects of evapotranspiration and albedo changes (Bonan, 2008) associated with forest management in specific forest types found in California? The climate benefit of temperate forests is more uncertain than either the tropical or boreal forests. Major disturbances—such as fire, insects or disease—add to the uncertainty (Canadell and Raupach, 2008; IPCC, 2007). Bonan (2008) identifies eddy covariance flux towers, free-air $CO_2$ enrichment systems, satellite sensors, and mathematical models as currently available tools to forest-climate researchers.

Invasive plants, insects, pathogens, and wildfire are potential mechanisms for catastrophic tree mortality that are difficult to incorporate into a modeling framework to project future forest condition. By constructing models that accurately track past disturbances we may begin to understand the range of impacts with various assumptions. This would be in addition to incorporating climate forcing and $CO_2$ fertilization effects into accurate forest models capable of being used for long-term planning and research.

The 2003 PIER research plan suggested that retrospective studies of climate and vegetation links be performed to inform future possibilities. To the extent that such studies may be reliably done, this is a logical approach to consider (Petit et al., 2008). For example, analysis of redwood pollen (Gardner et al., 1988) suggested that redwood responded rapidly to climate change and was more abundant before 5500 B.P. Before this time, the interior of California and the Great Basin were warmer, causing stronger pressure gradients, which created stronger winds and ocean upwelling, and in turn pushed fog more inland.

The integration of individual tree growth and mortality models into dynamic global vegetation models (DGVMs) was the subject of a paper by Purves and Pacala (2008). This would reduce a significant element of uncertainty in forest response to climate change and also to sequestration or emission potential over time. While this would take advantage of modeling techniques and long-term data, the challenge would be to integrate the submodels efficiently, in light of the computer processing constraints of DGVMs.

Finally, California's private forestlands are the most regulated in the United States. Many of the risk factors inherent in carbon offset projects are ameliorated by secure land tenure and the protection of co-benefits. However, the competitive nature of wood product commodities and high production costs can make forest projects very cost sensitive. The ability to reduce project costs by using existing regulatory and third-party forest certification systems may increase landowner participation. Refined information on market prices, project costs, and landowner behavior at given price points would allow the construction of more accurate supply curves for California.

## 7.0 Conclusions and Prioritized Recommendations

### 7.1 Conclusions

Overall forestry sector research priorities for the next three years are as follows:

- Statewide Forest Carbon Inventory and Change Tracking for 2020 Target Progress Monitoring;
- Urban Forests and Climate Change: Comprehensive Cost and Benefit Analysis;
- Predictive Tree Biomass Model Evaluation and Improvement;
- Wildfire GHG Emission Analysis: Standardized Estimation Methodologies;
- Life-Cycle Characterization of Forest Carbon Pools and Wood Products in California;
- Forest Landowner Profile Development: Current and Projected Forest Conditions and Landowner Participation in Programs and Markets;
- Improved Forest Research and Management Tools: Climate Smart Forest Projections and Risk Assessments for Pests and Fire;
- Forest Bioenergy and Biofuel GHG Profile Characterization;
- Climate Change and Forests Research and Monitoring Infrastructure Development: Joint Strategic Planning;
- Quantification of managed fire versus wild fire GHG emissions in California forests;
- Risk and prevention analysis of catastrophic tree mortality in California forests from exotic insects and disease; and

- A comprehensive monitoring and adaptive management program to quantify the effects on climate change and the effectiveness of adaptation strategies.

### 7.2 Prioritized Recommendations

Specific to the energy-related mission of PIER and the stated desire to have up to four years for results and impacts to policy, the following research priorities best fit:

- Forest Bioenergy and Biofuel GHG Profile Characterization;
- Urban Forests and Climate Change: Comprehensive Cost and Benefit Analysis;
- Life-Cycle Characterization of Forest Carbon Pools and Wood Products in California; and
- Improved Forest Research and Management Tools: Climate Smart Forest Projections and Risk Assessments for Pests and Fire.

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